# FIELD CROPS NORTH

## FUNGICIDE BENEFITS ASSESSMENT

National Agricultural Pesticide Impact Assessment Program (NAPIAP)

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# FIELD CROPS - NORTH

January, 1991

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This Report Represents a Portion of the USDA/States
National Agricultural Pesticide Impact Assessment Program (NAPIAP)
Fungicide Assessment Project

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# PREFACE

Plant diseases affect all the major food crops world-wide and must be controlled to prevent significant production losses and maintain food quality for animals and humans. In addition, fungicides are a necessary factor in maintaining the availability of fiber and landscape improvements ranging from forest management to enhancements through the use of ornamentals. Agricultural fungicides are a significant component in effective disease control and are critical to plant health management systems. Fungicides provide benefits to producers as well as consumers and to local as well as national economies. Farmers benefit from the prevention of yield losses, improved crop quality, enhanced market opportunities, facilitation of farmwork and harvest. Consumers also benefit from an ample, varied, safe, healthy and inexpensive food supply that is available throughout the year.

This is one of 11 separate reports that assessed the beneficial aspects of fungicide use in U.S. agriculture. The 11 reports, all using a commodity approach in evaluating fungicide use, comprise the Fungicide Benefits Assessment. This assessment represents one part of the USDA/States National Agricultural Pesticide Impact Assessment Program's Fungicide Assessment Project. The two other parts deal with (a.) a treatise examining the health and environmental factors associated with the agricultural use of fungicides, and (b.) an assessment of the status as well as the management strategies for fungal resistance to fungicides in the U.S.

The 11 Fungicide Benefits Assessment reports were prepared by a team of scientists (team leaders). The team leaders and the listing of their reports (by commodity) in the Fungicide Benefits Assessment are as follows:


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## I. INTRODUCTION

The compilation of this report and the acquisition of the data summarized herein were done under the direction of a Fungicide Benefits Assessment Team, convened by USDA-CSRS & NAPIAP to implement portions of "Assessment of the agricultural benefits of fungicide use in the United States -- a plan." The overall objectives of this plan were to:

A. Assemble and interpret information on the use of chemicals in agricultural practices to control fungal-induced diseases in agricultural products in the United States.

B. Assess the economic and biologic impact of fungicides on agricultural production and marketing (producer and consumer).

The Assessment Team's activities were apportioned to several smaller teams comprising major commodity groups. This is one of two reports produced by the Field Crops Team. The companion report, "Benefits from fungicide use in the United States on cotton, peanut, soybean, sugar beet, sugar cane, and tobacco," was compiled by Tom Kucharek, Team Leader, Field Crops - South. The purpose of the present report was to collect and compile the most accurate and up-to-date information available on the usage and agricultural benefits of fungicides on the following major field crops: field corn (commercial grain and silage production as well as hybrid seed production), popcorn, rapeseed (including canola), sunflower, forage legumes (including alfalfa), and forage grasses.

While the impetus for this project was the current review by the Environmental Protection Agency of ethylenebisdithiocarbamate fungicides (EBDC's), the scope of the project included all fungicides on all relevant agricultural commodities. It is expected that the data presented herein will be utilized over the period of ca. 1990-1995 in any regulatory decision concerning the labeling and registration of fungicides on the relevant field crops in the United States.

## II. METHODS AND APPROACH

Field corn and forage crop production are economically important in most regions of the United States. Therefore, information on the agricultural use and benefits of fungicides on these crops was sought from all relevant states. Some states were excluded because of relatively small acreage, lack of an information source, or lack of response on the part of the contacted expert. Data blanks should not be interpreted as a lack of benefit or importance of fungicides in these states. The data collection method was an expert survey conducted via telephone interview by the team leader with one or more experts in each state. Data were derived as responses to questions asked in the "Assessment of the agricultural benefits of fungicide use in the United States -- a plan" relative to each crop. Transcripts were made of these

conversations and, in some cases, the team leader had to use his best judgment in interpreting expert responses in order to conform to a common report format. A preliminary draft of this report was mailed to each state expert for further changes.

Data on production (e.g., acres planted, acres harvested, yields/acre, value of production) were derived from annual publications of the USDA Economic Research Service. Where production figures were not available from USDA, estimates were sought from state experts. The four production years 1985-1988 were used as a base for average production as well as for information on the use and benefits of fungicides. This method was thought useful in moderating the influence of environmentally atypical years such as 1988 (i.e., widespread drought).

Considerable thought was given to the choice of experts. Selection criteria included expertise in field crop pathology and local crop production practices and objectivity concerning the use of agrichemicals. The majority of experts contacted hold appointments as Extension plant pathologists in land grant universities. In most cases, estimates given by a single expert relied on collaborative input from state colleagues in research, extension, and agribusiness. All experts contacted considered this an important exercise and formulated their responses after careful consideration and consultation.

It should be strongly noted and underscored that most experts felt that their estimates of fungicide benefits were more indicative than reliable. Some experts would not provide quantitative estimates while others provided them with qualifying statements that are difficult to express in a summarized document.

The research base for estimating agronomic, nonetheless economic, benefits of fungicides is scant, especially for the extensively managed crops under consideration. That is the reason why an expert opinion survey was chosen over a survey of the published literature. Plant pathologists, as a group, are conservative and precise. If in doubt on their estimates, most erred on the side of claiming less crop loss (and hence, less fungicide benefit) than what may actually occur. The greatest value to be derived form this document is in judging the relative importance of various diseases, disease control strategies, and fungicides in production of specific field crops.

## III. COMMODITY REPORTS

### A. Corn (*Zea mays* L.) for commercial grain and silage production.

Corn is a major field crop in the U.S. with an average of 74.3 million acres planted each year during the period 1985-1988. The average annual area harvested during this period was 72.3 million acres, of which 65.4 million acres were for grain and 6.9 million acres were for silage. The majority of the U.S. corn crop is utilized domestically as animal feeds although significant portions of the crop are utilized in human food products and industrial uses or are exported for the same uses. Average annual grain production (silage not included) was valued at 14.7 billion dollars during 1985-1988. While field corn production occurs in virtually every state, seven north central states (Illinois, Indiana, Iowa, Minnesota, Nebraska, Ohio, and Wisconsin) account for ca. 70% of the U.S. corn acreage and 74% of grain production. Silage production is more evenly distributed but five major dairy states (California, Minnesota, New York, Pennsylvania, and Wisconsin) account for ca. 41% of corn silage production. Corn production statistics by state are provided in Table 1.

Nearly all (>95%) of field corn seed planted in the U.S. is treated by the seed supplier with a protectant fungicide for control of seed decay and seedling blights (Table 2). Captan in various formulations accounts for 85-95% (or greater) of this seed treatment. Other significant seed-applied fungicides include thiram, EBDC's, TCMTB, carboxin, and metalaxyl. In most states, no further seed treatment fungicide is applied by the farmer. In certain states, e.g., New York, Ohio, West Virginia, a small but significant percentage of farmers apply a planter box treatment of fungicide (primarily captan) in combination with insecticides (Table 2). Although enhanced seed rot/seedling blight control is expected from these applications, the principal purpose is control of seed corn maggot and other soil insects by the insecticidal component. Table 3 lists typical seed treatment fungicide formulations. Yield losses in the absence of seed fungicides are difficult to estimate as losses vary considerably with region, growing season, and even local field conditions. Estimates of yield loss given in Table 4 are highly indicative. Protectant seed-applied fungicides affect primarily the initial plant population, although secondary effects on seedling vigor may also affect other components of yield. Local stand reductions due to seed rots and seedling blights range, literally, from 0 to 100%. Moderate stand reductions often result in minimal yield impacts due to compensatory abilities of surviving plants. Yield loss potential, and hence, fungicide benefit, is greatest in areas where seed is planted into cool, wet soils (i.e., conditions conducive to pathogen development and nonconducive for rapid seed germination and seedling development). The need for seed

treatment is relatively greater in conjunction with early spring planting. Average losses of 10% or greater in the absence of any seed treatment fungicide were predicted for ten states (Illinois, Iowa, Kansas, Missouri, Nevada, North Carolina, Tennessee, Vermont, Wisconsin, and Wyoming). Projected annual losses in the two major production states of Illinois and Iowa alone amount to 277 million bushels of grain valued at 559 million dollars (1985-1988). Several states (e.g., Arizona, California, Colorado, Delaware, Washington) estimated negligible overall benefits of seed fungicides while acknowledging that losses may occur in individual fields. A majority of experts estimated average annual losses in the absence of seed fungicides at 4-8% in their state.

All experts were asked to comment on the effects of banning captan while maintaining other seed fungicides. Many felt that thiram or EBDC's were virtually equivalent to captan in broad spectrum seed decay/seedling blight control. Ironically, these materials will be subject to registration review before or at the same time as captan. Others felt that neither thiram nor EBDC's were as efficacious as captan. Thiram also elicits a severe allergic response in certain seed handlers. EBDC's were cited as being less efficacious against <u>Pythium</u> spp. TCMTB was considered comparable in Illinois in disease control but has been shown to be phytotoxic to certain corn genotypes. Carboxin was considered an alternative to captan in a few states where there were problems with seedborne head smut. Metalaxyl is efficacious against <u>Pythium</u> spp. but is too narrow spectrum for use alone, and metalaxyl resistance problems may develop in soil populations of <u>Pythium</u> spp. PCNB was also thought to be too narrow spectrum for seed protection in diverse soil environments. Apart from disease control efficacy, a major reason for maintaining captan as a seed treatment is that it is the only seed dressing that can be detreated and the grain fed to livestock. This provides tremendous economic flexibility to seed companies to utilize treated grain for seed or as feed. Nonplanted seed treated with any other pesticide must be disposed of as a hazardous waste at great expense and inconvenience.

Foliar fungicides are not used on any significant portion of commercial field corn acreage in the United States. Until its voluntary withdrawal in 1990, one product, mancozeb (Manzate 200 DF) was labeled for control of rusts and 'Helminthosporium leaf blights' (i.e., northern leaf blight, southern leaf blight, and northern leaf spot). It could be applied at a rate of 1.1 lb A.I./acre at 4-7 day intervals to within 40 days of harvest. No experts interviewed felt that foliar fungicides would or should become a standard production practice on field corn. However, the reinstatement of the mancozeb label for field corn was considered essential for emergency use in the event of a major epidemic such as occurred with southern corn leaf blight in 1970 and 1971.

Many fungal, bacterial, and viral diseases attack corn and could potentially reduce corn yields. Overall, field corn is a rather healthy crop in the U.S. Most experts felt that averaged over years and locations, diseases did not cause major economic losses in field corn during 1985-1988. Table 5 lists several states where diseases did cause economic loss during this period despite disease control strategies (i.e., fungicide seed treatment, resistant varieties, good cultural practices) that were already in place. Stalk rots and ear rots were the most commonly mentioned diseases. Both are endemic and losses depend on interactions with environmental factors. Fungicides are not currently promising in control of these diseases. Additional gains, although slow and complex, may be expected in genetic improvement of corn hybrids to control these diseases. Gray leaf spot was the most often mentioned foliar disease causing losses during 1985-1988. Fungicides may be necessary for emergency application to save corn crops in areas where gray leaf spot resistance has not yet been incorporated into adapted hybrids.

B. Corn (<u>Zea</u> <u>mays</u> L.) for hybrid seed production.

Male and female inbred parents are grown in order to produce hybrid seed for the commercial field corn production discussed above. Seed corn production occurs annually on ca. 750,000 acres of land in the U.S. (precise figures unavailable). The largest portion of this production is in Iowa and Illinois with large areas also in Nebraska, Minnesota, Indiana, and Wisconsin. Mr. Bill Shapiro of the American Seed Trade Association (personal communication) estimated conservatively that 25 million bags (1 bag plants ca. 3.4 acres) of seed corn are produced each year. Of these, ca. 23 million bags are planted domestically, 1 million bags are sold overseas, and 1 million bags need to be discarded. More than 95% of inbred seed is treated with a fungicide, primarily captan. Estimated average losses in the absence of seed treatment range from 2 to 15%, with estimated losses of 8-10%, in the major production states of Iowa and Illinois. The spectrum of organisms causing seed rot and seedling blight are the same as for commercial field corn. As with hybrid seed, most experts felt that thiram or EBDC's were the only acceptable alternatives to captan for treatment of inbred seed.

Corn inbreds (especially predominantly used female parents) are relatively more susceptible and vulnerable to fungal leaf blights than are corn hybrids. Substantial losses to foliar blights would be incurred in the absence of foliar fungicides (Table 7). Losses occur as much or more in reduced seed size and vigor as in decreased yield. Mancozeb (registration voluntarily cancelled in 1990) and chlorothalonil were labeled for control of Helminthosporium leaf blights and rusts (Table 8), but mancozeb was the predominant fungicide used and the one preferred for efficacy (Table 7). Intensity of mancozeb application ranged from single applications in Iowa and Illinois to 3-4 applications in Ohio and Pennsylvania (Table 7). Limited applications of propiconazole (Tilt) have been made under FIFRA Section 18 permits in several states. Based on biological activity, propiconazole is a suitable alternative to mancozeb for leaf blight control, but it is more expensive and poses a possible risk for development of fungicide-resistant fungus strains.

C. Popcorn (<u>Zea</u> <u>mays</u> L.)

Popcorn for snack foods is a major specialty field crop in the U.S. Indiana is the top production state with major acreages also in Nebraska, Iowa, Illinois, Kentucky, and Ohio. Precise production statistics were unavailable. Nearly all seed is treated with fungicide for control of seed rots and seedling blights (Table 9). Most of the seed is treated with captan, but a significant percentage is treated with thiram. Most experts felt that captan and thiram were equivalent in disease control.

Illinois is the only state where widespread use of foliar fungicides (mancozeb formulations) was reported during 1985-1988 (Table 10). However, several plant pathologists felt that mancozeb registration should be maintained for emergency control of leaf blights and rusts. Experts in California and Iowa stated that economic (associated with crop quality as well as yield) losses were currently being incurred in association with fungal ear and kernel rots.

Another specialty corn type that should be mentioned here is native blue corn for utilization in specialty food products. Approximately 3.8 million pounds of grain are produced annually in New Mexico. All of the seed for this crop is treated with fungicide (primarily captan). There are no foliar fungicides used.

Sweet corn is covered under the Fungicide Benefits Assessment reports for Vegetables by M. Davis and S. Johnston.

## D. Rapeseed (*Brassica napus*) including canola

Rapeseed is the world's fourth largest oilseed crop. The term canola refers to varieties of rape that have been certified (by the Canadian government) to meet minimal standards for erucic acid content in extracted oil and glucosinolate content in the residual meal. Relatively small acreages of canola were grown in the U.S. in 1985-1988 (Table 12) but a majority of state agricultural experiment stations have done research to explore canola's utility as an alternative field crop. It is anticipated that canola acreage will increase dramatically in the next five years concurrent with increased use of canola oil in U.S. vegetable oil products. Canola oil has been shown to have dietary, stability, and cooking characteristics superior to several other vegetable oils. Montana provides an example of the perceived potential of canola. Production there is expected to rise from a few fields in 1989 to one-half million acres in 1990.

Benomyl and captan are currently the only fungicides labeled for seed treatment of rapeseed (Table 13). Seed treatment use is erratic and specific to state (Table 12). The primary seed treatment seems to be benomyl used to prevent the introduction of a highly virulent strain of *Phoma lingam*, causal fungus of blackleg, via infected seed into areas where the new strain does not exist. The first report of heavy losses to this new strain in the U.S. occurred in southwestern Kentucky in 1989. Most production states currently use no seed treatment, while in states such as Georgia, Kentucky, North Dakota, and Tennessee, nearly all of the seed is treated with benomyl. Crop losses as high as 10% to the new strain of blackleg were estimated for North Dakota if seed were not treated with benomyl. In Europe and Canada captan was found to be less effective than benomyl seed treatment in blackleg control.

There are currently no foliar fungicides labeled for use on rapeseed. This may ultimately limit the profitable production of canola in several regions of the U.S. Only a few states report significant disease-induced losses in the small areas now under cultivation (Table 12). However, several plant pathologists predicted that Sclerotinia stem rot, Phoma black leg, and Alternaria leaf spot would become major problems as the acreage expanded. Also mentioned were Cercospora leaf spot, Phytophthora root rot, and Rhizoctonia root rot.

E. Sunflower (Helianthus annuus L.)

Sunflower for vegetable oil, confectionery use, and bird seed is grown on ca. 2.2 million acres with a production of 2.5 billion pounds valued at 208 million dollars in 1985-1988. More than 75% of this production occurred in one state, North Dakota (Table 14). Significant acreages also occur in Kansas, Michigan, Minnesota, South Dakota, and Texas.

Captan, thiram, and metalaxyl are labeled for seed treatment of sunflower (Table 16). Captan and thiram are effective in control of seed decay and seedling blights and one or the other is used in several sunflower states (Table 15). Eighty to 90% of the seed in North Dakota is treated with metalaxyl for control of seedborne downy mildew. Five percent losses to downy mildew were predicted in the absence of metalaxyl seed treatment (Table 15).

Foliar fungicides are not routinely used in the production of sunflower. In 1989, 25,000 to 30,000 acres in North Dakota were sprayed with mancozeb under the provisions of FIFRA Section 18 for emergency control of a new race of rust. A Section 18 label was granted again in 1990. A small acreage in Minnesota was also sprayed with mancozeb for rust control under a Section 18 label. Sulphur fungicides have been used for rust control on a small acreage of sunflower in California. A federal label for mancozeb (rust control) is desirable as genetic resistance to rust is not durable. When new races appear, emergency fungicide treatments may be necessary.

Several diseases afflict sunflower. However, Sclerotinia diseases (Sclerotinia wilt, middle stalk rot, and head rot) and rust were the only diseases thought to be causing significant yield losses under current production practices. Several state experts specifically cited unsolvable problems with Sclerotinia diseases as a reason why sunflower production was no longer profitable in their states.

## F. Alfalfa (*Medicago sativa* L.)

Alfalfa is the most important forage crop in the United States with an average annual production of 82.6 million tons of hay (or equivalent) produced on 26.1 million acres (Table 17). These figures do not include the alfalfa seed production acreage in several western states.

Relatively little fungicidal seed treatment was used prior to 1985. An exception was the use of thiram to reduce the introduction of seedborne *Verticillium albo-atrum* into areas where Verticillium wilt had not been found. That practice continues in Vermont (Table 18). Typical formulations of fungicides for seed treatment are listed in Table 19. Most of the reported seed treatment usage in the U.S. during 1985-1988 was with metalaxyl for control of early season Phytophthora root rot and Pythium root rot/damping-off. Metalaxyl treatment is done primarily by the seed supplier and is often tied to alfalfa variety. Plant pathologists feel that Phytophthora root rot control is best accomplished by using metalaxyl seed treatment on seed of varieties already resistant to the disease. Seed treatment usage on alfalfa is in transition from no use in the early 1980's to projections of nearly all of seed treated with metalaxyl in certain regions in the early 1990's. A label is pending acceptance for Ridomil (soil-applied metalaxyl) on alfalfa which may increase the total usage of metalaxyl on the crop while reducing the amount applied via seed. Soil application has the reputed agricultural advantages of both earlier and more residual activity against *Phytophthora* and *Pythium* spp. Losses due to *Pythium* and *Phytophthora* which can be prevented by seed- (or soil-) applied metalaxyl are extremely difficult to estimate. State estimates ranged from 0 to 25% average annual losses (Table 18). Vulnerability to these diseases is tied to locations and times of planting when soils are waterlogged during the first several weeks after sowing. Because of this connection with soil environment, stand losses in individual fields range from 0 to 100%. Metalaxyl has proven highly effective in reducing initial stand losses to *Pythium* and *Phytophthora*. However, a crop can withstand moderate reductions in initial stand and still yield at acceptable levels due to the compensation ability of the surviving plants.

Although copper compounds are registered for leaf spot control on alfalfa (Table 20), an insignificant number of fields has been sprayed (specific reports in New Jersey and Ohio). Very little research has been conducted on the efficacy of these materials. The fungal leaf spot complex was reported to be causing economic losses under present management schemes in many states (Table 21). In Illinois research results indicated a 200% return on investment using foliar mancozeb (not labeled) for control of the leaf spot complex. Similar research in Wisconsin indicated that mancozeb or

benomyl prevented a 20% yield reduction due to leaf spots. Only low levels of resistance currently exist to foliar pathogens in adapted alfalfa cultivars. The registration of inexpensive protectant fungicides such as mancozeb might greatly enhance the yield and profitability of alfalfa.

G. Other forage legumes

Several species of clovers and other forage legumes such as sanfoin, birdsfoot trefoil, and perennial peanuts are regionally important forage crops. Economic losses to diseases are incurred under current production practices with these crops; however, fungicides are seldom used. No foliar fungicides are labeled. Seed treatment fungicides are essentially the same as those labeled for alfalfa (Table 19), but only a minuscule fraction of the crop seed is treated. One exception is the treatment in Oregon of crimson clover seed (for seed production) with thiabendazole (FIFRA 24c Special Registration) for control of seedborne northern anthracnose caused by *Kabatiella caulivora*. Losses in the absence of this treatment were estimated to average 5% with a range of 0 to 100%.

H. Forage grasses

Grass species including fescues, brome, orchardgrass, ryegrass, bermudagrass, canarygrass, timothy, bahiagrass, etc. are grown on large acreages in the U.S. in pastures and hayfields (Table 17, all other hay) as pure stands or as mixtures with legumes or other grasses. Fungal diseases are often considered to be of minor economic importance but the research on which such conclusions are based is scant. Fungicides are registered for seed treatment (Table 22), but almost none are used. No foliar fungicides are labeled.

Although fungicide usage on grain sorghum is covered in the report on "Fungicide benefits in cereals" by Greg Shaner, Team Leader, Cereals, sorghum is widely grown as a forage crop in the states of Colorado, Kansas, Oklahoma and Texas. Nearly all of that seed is treated with captan for control of seed decay and seedling blights (1-2% losses were estimated in the absence of captan seed treatment). PCNB was considered an alternative fungicide for this use in Oklahoma.

## IV. CONCLUSIONS

The field crops under consideration are, with the exception of seed production, extensively managed crops in which disease control is accomplished principally by selecting disease-resistant crop cultivars and using appropriate crop management methods (e.g., cropping sequence, selection of planting site, balanced fertilization, seedbed preparation, date of planting, seeding rate and depth). This situation is not expected to change substantially. However, cultural practices and genetic resistance (lacking or at low level for many diseases) alone often are insufficient to provide economic disease control. Fungicides have a legitimate and necessary role in integrated strategies to protect U.S. field crops from disease-induced reductions in yield and quality. The following major conclusions concerning fungicide use and benefits on field crops represent a consensus of opinion of state experts.

A. It is essential that efficacious protectant fungicides remain available for seed treatment of corn (hybrid field corn, inbreds for seed production, and popcorn) to prevent significant losses from seed decay and seedling blights caused by a wide range of microorganisms. It is important that one registered material be available which allows the option of detreating treated seed for use as livestock feed or entry into other market channels. Currently, captan is the only material for which this use is allowed. Most experts feel that captan is the fungicide of choice for corn seed treatment followed in decreasing priority by thiram and EBDC's.

B. Until another efficacious fungicide (e.g., propiconazole) is registered, the registration of foliar mancozeb should be reinstated for the control of fungal leaf blights and rust in all types of corn. Mancozeb is needed for emergency (i.e., where resistant varieties are unavailable) suppression of leaf blight epidemics in field corn and popcorn, but is critical for routine use in the production of hybrid field corn seed. Even if systemic foliar fungicides such as propiconazole are registered for corn, the availability of mancozeb (as an alternative spray) may be important in managing fungal populations that could potentially become resistant to ergosterol biosynthesis inhibitor fungicides.

C. Benomyl seed treatment appears to be preventing serious losses in rapeseed associated with seedborne *Phoma lingam*. Its registration for rapeseed should be maintained. There is a potential for benomyl-resistant *Phoma* strains to be selected. Therefore, integrated control schemes should be employed.

D. The registrations of captan, thiram, and metalaxyl as seed treatments on sunflower should be maintained. The registration of foliar mancozeb on sunflower should be maintained for emergency control of new races of rust which occasionally appear.

E. The registration of metalaxyl seed treatment for control of Phytophthora root rot and Pythium root rot/damping-off in alfalfa should be maintained. Concern was expressed about the potential of selecting for metalaxyl resistance in *Phytophthora* and *Pythium* populations (in response to widespread use of seed- and soil-applied metalaxyl) and the need to employ alternative and integrated control strategies.

F. Only a small percentage of plant pathologists interviewed feel that protectant seed treatment fungicides are important in the production of most forage legumes or grasses. There may be agricultural justification for the use of foliar mancozeb (currently labeled for turf but not forage grasses) for emergency rust and leaf spot control in the production of seed of forage grasses. For specific forage legumes and grasses, there may be justification for the use of fungicidal seed treatments (especially in seed production) but there were insufficient data to draw any conclusions.

## V. RESEARCH AND DATA NEEDS

The expert survey revealed large gaps in knowledge on the regional occurrence of diseases, disease-induced losses, overall fungicide benefits, and comparative benefits of alternative fungicides in the extensively managed field crops under consideration. Data gaps exist because of insufficient funding and professional recognition for crop loss assessment research and the scarcity of state pesticide use and disease damage surveys. More regional research of the type exemplified in the article (Pedersen, W. L., J. M. Perkins and D. G. White, 1986. Evaluation of captan as a seed treatment for corn. Plant Disease 70:45-49) is needed as a basis for fungicide benefits assessment. In almost every crop, economic losses were being incurred under current management practices. This indicates a tremendous potential for crop improvement involving cultural practices, breeding for disease resistance, and in some cases, the use of fungicides. Special research needs and opportunities were apparent in the following areas.

A. Assessment of the comparative benefits of fungicide alternatives to captan in seed treatment of corn in diverse locations and growing seasons.

B. Assessment of cultural practices in control of corn diseases, especially stalk and ear rots.

C. Improvement of corn varieties for resistance to anthracnose, Pythium, and perhaps other stalk rots (prior efforts have emphasized stalk architecture, i.e., standability, rather than resistance), ear rots, and leaf blight (e.g., widespread need for gray leaf spot resistance).

D. Research into all aspects of disease management in canola as this crop expands acreage in the next five years. Special emphasis should be placed on management of blackleg and Sclerotinia stem rot.

E. Development of improved disease management strategies for Sclerotinia diseases of sunflower.

F. Improvement of alfalfa varieties for resistance to fungal leaf spots, and crown and root rots.

G. Assessment of the potential benefits of foliar fungicides such as copper compounds (registered) and mancozeb (not registered) in leaf spot control in alfalfa.

H. Assessment of integrated management schemes for control of Phytophthora and Pythium root rots on alfalfa and potential for development of metalaxyl-resistant pathogen populations.

I. Assessment of the benefits of fungicide (seed- and foliar-applied) use in production of seed of various forage legumes and grasses.

Table 1. Field corn production statistics by state, 1985-1988.

| STATE | All purposes Area planted (1000 A) | % US Acre | Grain:Area Harvested (1000 A) | Grain Yield/ Harvested A (Bushels) | Grain Prod. (1000 Bu) | % US Grain Production | Grain Prod.value ($1000) | Silage:Area Harvested (1000 A) | Silage Yield/A (Tons) | Silage Prod. (1000 T) | % US Silage Prod. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AL | 313 | 0.43 | 254 | 62.00 | 16311 | 0.22 | 39235 | 25 | 9.73 | 241 | 0.27 |
| AZ | 30 | 0.04 | 21 | 111.25 | 2264 | 0.03 | 5681 | 9 | 24.52 | 227 | 0.25 |
| AR | 76 | 0.10 | 70 | 107.28 | 7460 | 0.10 | 15371 | 6 | 11.00 | 61 | 0.07 |
| CA | 463 | 0.63 | 237 | 148.00 | 35004 | 0.48 | 95008 | 220 | 23.75 | 5231 | 5.88 |
| CO | 852 | 1.16 | 734 | 148.53 | 109477 | 1.50 | 198992 | 108 | 22.48 | 2440 | 2.74 |
| CT | 51 | 0.07 | | | | 0.00 | | 52 | 18.53 | 953 | 1.07 |
| DE | 170 | 0.23 | 158 | 83.72 | 13426 | 0.18 | 30877 | 10 | 12.03 | 109 | 0.12 |
| FL | 168 | 0.23 | 130 | 64.22 | 8400 | 0.12 | 21608 | 14 | 13.38 | 191 | 0.21 |
| GA | 815 | 1.11 | 704 | 71.97 | 51620 | 0.71 | 128354 | 45 | 10.53 | 475 | 0.53 |
| ID | 131 | 0.18 | 60 | 128.72 | 7700 | 0.11 | 18287 | 67 | 22.40 | 1495 | 1.68 |
| IL | 12338 | 16.82 | 10118 | 118.75 | 1210238 | 16.61 | 2592867 | 187 | 13.73 | 2410 | 2.71 |
| IN | 5538 | 7.55 | 5383 | 115.78 | 624663 | 8.57 | 1288464 | 126 | 15.63 | 1937 | 2.18 |
| IA | 11950 | 16.29 | 11587 | 118.72 | 1384838 | 19.01 | 2610955 | 318 | 14.48 | 4168 | 4.68 |
| KS | 1325 | 1.81 | 1209 | 127.78 | 154753 | 2.12 | 301951 | 101 | 14.90 | 1501 | 1.69 |
| KY | 1518 | 2.07 | 1330 | 92.72 | 124455 | 1.71 | 279569 | 166 | 13.88 | 2308 | 2.59 |
| LA | 248 | 0.34 | 239 | 107.53 | 25567 | 0.35 | 60097 | 11 | 12.73 | 131 | 0.15 |
| ME | 40 | 0.05 | | | | 0.00 | | 33 | 15.73 | 514 | 0.58 |
| MD | 631 | 0.86 | 525 | 81.50 | 43980 | 0.60 | 105891 | 102 | 11.50 | 1164 | 1.31 |
| MA | 42 | 0.06 | | | | 0.00 | | 35 | 18.75 | 666 | 0.75 |
| MI | 2575 | 3.51 | 2183 | 93.78 | 210288 | 2.89 | 432075 | 360 | 11.85 | 4144 | 4.66 |
| MN | 6225 | 8.49 | 5450 | 109.47 | 603725 | 8.29 | 1167524 | 620 | 11.45 | 6631 | 7.45 |
| MS | 195 | 0.27 | 158 | 70.72 | 11280 | 0.15 | 26919 | 28 | 12.10 | 344 | 0.39 |
| MO | 2475 | 3.37 | 2268 | 103.75 | 237498 | 3.26 | 463901 | 103 | 12.28 | 1187 | 1.33 |
| MT | 83 | 0.11 | 15 | 106.25 | 1579 | 0.02 | 3177 | 66 | 18.77 | 1233 | 1.39 |
| NE | 7125 | 9.71 | 6812 | 127.75 | 870050 | 11.94 | 1619884 | 243 | 15.73 | 3826 | 4.30 |
| NV | | 0.00 | | | | 0.00 | | | | | 0.00 |
| NH | 26 | 0.04 | | | | 0.00 | | 23 | 18.62 | 437 | 0.49 |
| NJ | 123 | 0.17 | 114 | 99.25 | 10000 | 0.14 | 22887 | 21 | 14.28 | 310 | 0.35 |
| NM | 79 | 0.11 | 56 | 153.72 | 8611 | 0.12 | 18865 | 20 | 20.75 | 419 | 0.47 |
| NY | 1150 | 1.57 | 584 | 97.00 | 56649 | 0.78 | 126150 | 547 | 13.98 | 7660 | 8.61 |
| NC | 1442 | 1.97 | 1266 | 72.97 | 92334 | 1.27 | 205662 | 122 | 10.90 | 1343 | 1.51 |
| ND | 862 | 1.18 | 493 | 79.00 | 39538 | 0.54 | 78070 | 298 | 5.85 | 1705 | 1.92 |
| OH | 3662 | 4.99 | 3443 | 115.00 | 401342 | 5.51 | 826513 | 192 | 15.15 | 2826 | 3.18 |
| OK | 80 | 0.11 | 58 | 106.03 | 6050 | 0.08 | 12847 | 18 | 16.02 | 286 | 0.32 |
| OR | 59 | 0.08 | 28 | 161.97 | 4591 | 0.06 | 11482 | 29 | 23.50 | 682 | 0.77 |
| PA | 1620 | 2.21 | 1148 | 92.00 | 108517 | 1.49 | 271767 | 462 | 13.98 | 6320 | 7.10 |
| RI | 4 | 0.01 | | | | 0.00 | | 4 | 17.50 | 57 | 0.06 |
| SC | 478 | 0.65 | 423 | 67.53 | 28900 | 0.40 | 62553 | 36 | 10.38 | 363 | 0.41 |
| SD | 3265 | 4.45 | 2750 | 76.00 | 211487 | 2.90 | 398532 | 445 | 6.50 | 2681 | 3.01 |
| TN | 817 | 1.11 | 673 | 84.03 | 56958 | 0.78 | 122985 | 130 | 12.78 | 1657 | 1.86 |
| TX | 1438 | 1.96 | 1355 | 105.00 | 142190 | 1.95 | 314101 | 51 | 17.27 | 857 | 0.96 |
| UT | 73 | 0.10 | 19 | 126.03 | 2865 | 0.04 | 5391 | 52 | 20.15 | 1041 | 1.17 |
| VT | 101 | 0.14 | | | | 0.00 | | 90 | 15.10 | 1351 | 1.52 |
| VA | 637 | 0.87 | 387 | 73.75 | 29564 | 0.41 | 67770 | 234 | 11.63 | 2650 | 2.98 |
| WA | 150 | 0.20 | 104 | 167.53 | 17300 | 0.24 | 40387 | 46 | 24.02 | 1103 | 1.24 |
| WV | 94 | 0.13 | 54 | 81.25 | 4971 | 0.07 | 10888 | 30 | 12.78 | 377 | 0.42 |
| WI | 3800 | 5.18 | 2800 | 102.47 | 296325 | 4.07 | 626918 | 960 | 11.85 | 10529 | 11.83 |
| WY | 96 | 0.13 | 51 | 111.28 | 5673 | 0.08 | 10674 | 42 | 18.00 | 746 | 0.84 |
| US | 73362 | 100.00 | 65429 | 110.17 | 7285476 | 100.00 | 14731030 | 6900 | 13.18 | 88981 | 100.00 |

Source: USDA Economic Research Service

Table 2. Field corn seed treatment usage, 1985-1988

| STATE | 1985-1988 All Purpose Area Planted (1000 Acres) | 1985-1988 % US Acreage | % Seed treated by seed supplier: Total | captan | other | % Seed treated by farmer (Planter box) | Information source |
|---|---|---|---|---|---|---|---|
| AL | 313 | 0.43 | | | | | |
| AZ | 30 | 0.04 | 00 | NA | NA | 0 | Richard Hine |
| AR | 76 | 0.10 | | | | | |
| CA | 463 | 0.63 | 100 | 100 | 0 | 0 | Mike Davis |
| CO | 852 | 1.16 | 100 | >90 | NA | NA | Bob Croissant |
| CT | 51 | 0.07 | | | | | |
| DE | 170 | 0.23 | 100 | 100 | 0 | 0 | Bob Mulrooney |
| FL | 168 | 0.23 | 100 | 99 | 1 (thiram) | 0 | Tom Kucharek |
| GA | 815 | 1.11 | 100 | NA | NA | 0 | James Hadden |
| ID | 131 | 0.18 | 100 | NA | NA | 0 | Robert Forster |
| IL | 12338 | 16.82 | 100 | 90 | 6(TCMTB), 4(thiram + carboxin) | <3 (captan) | Walker Kirby |
| IN | 5538 | 7.55 | 100 | 80 | 15 (thiram) 5 (carboxin) | 0 | Don Scott |
| IA | 11950 | 16.29 | 100 | 95 | NA | 0 | Laura Sweets |
| KS | 1325 | 1.81 | 100 | 100 | 0 | <1 (captan) | Douglas Jardine |
| KY | 1518 | 2.07 | 95 | 90 | thiram, some maneb mancozeb, zineb | 5 (captan) | Donald Hershman |
| LA | 248 | 0.34 | 100 | 85 | NA | 0 | Clayton Hollier |
| ME | 40 | 0.05 | | | | | |
| MD | 631 | 0.86 | 99 | 99 | 0 | 0 | Arvydas Grybauskas |
| MA | 42 | 0.06 | 100 | 98 | 2(thiram) | 0 | Dan Cooley |
| MI | 2575 | 3.51 | 100 | 100 | 0 | 0 | Pat Hart |
| MN | 6225 | 8.49 | 100 | 95 | NA | 0 | Ward Stienstra |
| MS | 195 | 0.27 | 100 | 90 | 10(thiram) | 0 | William Moore |
| MO | 2475 | 3.37 | 100 | 90 | 10(thiram, metalaxyl combinations) | <1 | Einar Palm |
| MT | 83 | 0.11 | 95 | NA | NA | 0 | Jack Riesselman |
| NE | 7125 | 9.71 | 95 | 85 | NA | <5 (captan) | David Wysong |
| NV | | 0.00 | 100 | 100 | 0 | 0 | John Maxfield |
| NH | 26 | 0.04 | | | | | |
| NJ | 123 | 0.17 | 100 | 15 | 70 (thiram), 15 (maneb) | 0 | Jack Springer |
| NM | 79 | 0.11 | 100 | NA | NA | 0 | Michael English |
| NY | 1150 | 1.57 | 100 | 98 | 2(TCMTB,thiram) | 10 (captan)* | Gary Bergstrom |
| NC | 1442 | 1.97 | 100 | 100 | 0 | 0 | Harry Duncan |
| ND | 862 | 1.18 | 100 | 100 | 0 | 0 | Marcia McMullen |
| OH | 3662 | 4.99 | 100 | 100 | 0 | 15 (captan) | Patrick Lipps |
| OK | 80 | 0.11 | 100 | 98 | NA | 0 | Ervin Williams |
| OR | 59 | 0.08 | 100 | 70 | 30 (thiram) | 0 | Paul Koepsell |
| PA | 1620 | 2.21 | 100 | 95 | NA | 0 | John Ayers |
| RI | 4 | 0.01 | | | | | |
| SC | 478 | 0.65 | 90 | 75 | 15 (thiram), trace (carboxin + metalaxyl) | 0 | Bruce Martin |
| SD | 3265 | 4.45 | 95 | 85 | 10(thiram,maneb) | 0 | Dale Gallenberg |
| TN | 817 | 1.11 | 85 | 80 | 5(thiram) | 0 | Melvin Newman |
| TX | 1438 | 1.96 | 100 | NA | thiram | 0 | Wendell Horne |
| UT | 73 | 0.10 | NA | NA | thiram | 0 | Sherman Thompson |
| VT | 101 | 0.14 | 100 | 98 | 2(thiram) | 0 | Al Gotlieb |
| VA | 637 | 0.87 | 100 | 100 | 0 | 0 | Erik Stromberg |
| WA | 150 | 0.20 | <20 | NA | thiram | 0 | Otis Malloy |
| WV | 94 | 0.13 | 95 | 95 | 0 | 10 (captan)* | John Baniecki |
| WI | 3800 | 5.18 | 100 | 100 | | <1 (captan) | Craig Grau |
| WY | 96 | 0.13 | 97 | 85 | NA | 0 | Paul Vincelli |
| US | 73362 | 100.00 | | | | | |

* Target = seed corn maggot

Table 3. Typical fungicide formulations available during 1985-1988 for application to seed of field corn for control of seed decay and seedling blights.

| Fungicide | Formulated products | Method* | %A.I. | Application rate (oz/cwt.) product | A.I. |
|---|---|---|---|---|---|
| captan | Captan 30 DD | C | 30 | 1.5 | 0.45 |
| | Captan 300 | C | 30 | 1.5 | 0.45 |
| | Captan 400 | C | 38 | 1.25-2.4 | 0.5-0.9 |
| | Captan 400 D | C | 38 | 1.25-2.4 | 0.5-0.9 |
| | Captan 75% | C | 75 | 1.25 | 0.9 |
| | Captan 4000 | C | 38 | 1.75 | 0.7 |
| | Captan 65 Sprills | C | 62 | 2.0 | 1.3 |
| carboxin | Vitavax 34 | C | 34 | 1.0-4.0 | 0.7-1.4 |
| | Vitavax Flowable | C | 34 | 2.0-4.0 | 0.7-1.4 |
| | Vitavax 25 DB | PB | 25 | 4.0-6.0 | 1.0-1.3 |
| mancozeb | Dithane M-45 | C | 80 | 2.7-5.4 | 2.2-4.3 |
| | Dithane F-45 | C | 37 | 4.3-8.6 | 3.4-6.8 |
| | Dithane DF | C | 75 | 2.9-5.8 | 2.3-4.6 |
| | Manzate 200 DF | C | 75 | 2.7-5.4 | 2.2-4.3 |
| metalaxyl | Apron Dry | PB | 13 | 3.0-4.0 | 0.4-0.5 |
| | Apron 25W | C | 25 | 4.0-1.4 | 1.0-3.5 |
| | Apron FL | C | 28.4 | 0.75-1.5 | 2.0-4.3 |
| | Apron Flowable | C | 28.4 | 0.75-1.5 | 2.0-4.3 |
| PCNB | RTU-PCNB | C | 24 | 3.0 | 0.72 |
| TCMTB | Nusam 30 EC | C | 30 | 1.5 | 0.45 |
| thiram | Thiram 30 | C | 30 | 3.8 | 1.1 |
| | Gustafson 42-S | C | 42 | 1.5 | 0.6 |
| | Thiram 50 WP | C | 50 | 3.0 | 1.5 |
| PCNB + metalaxyl | Apron - Terraclor | PB | 25,6 | 2.0 | 0.5,0.12 |
| PCNB + etridiazol | Terra-Coat L205N | C | 23,6 | 2.0 | 0.46,0.12 |
| | Terraclor Super X | PB | 20,5 | 2.0 | 0.2,0.1 |
| Fungicide + insecticide products | | | | | |
| captan + diazinon | Blue Ribbon Protector | PB | 37 | 4.0-12.0 | 1.5-4.5 |
| | Agrox-2 Way | PB | 36 | 4.0 | 1.4 |
| | Captan Diazinon Seed Protectant | PB | 12 | 8.0 | 1.0 |
| captan + lindane | Isotox Seed Protectant | PB | 12 | 8.0 | 1.0 |
| captan + methoxychlor | Captan Methoxychlor | C | 71 | 1.25 | 0.9 |
| carboxin + maneb + lindane | Enhance Plus | PB | 20,35 | 3.0 | 0.6-0.7 |
| | Germate Plus | PB | 14 | 3.6 | 0.5 |
| | Agrox DL-Plus | PB | 14 | 4.0 | 0.6 |

*Many seed treatment fungicides are available for use only by commercially certified seed treaters (C) while others are available for on-farm application in the planter box (PB).

Table 4. Estimated losses (average 1985-1988) in field corn in the absence of all seed fungicides.

| STATE | % Loss w/out seed fungicide | Estimated Grain Loss (1000 Bu) | Estimated $ Loss (Grain) ($1000) | Estimated Silage Loss (1000 Tons) | Information source |
|---|---|---|---|---|---|
| AL | | | | | |
| AZ | 0 | 0 | 0 | 0 | Richard Hine |
| AR | | | | | |
| CA | 0 | 0 | 0 | 0 | Mike Davis |
| CO | 0 | 0 | 0 | 0 | Bob Croissant |
| CT | | | | | |
| DE | 0.5 | 67 | 154 | 1 | Bob Mulrooney |
| FL | NA | NA | NA | NA | Tom Kucharek |
| GA | NA | NA | NA | NA | James Hadden |
| ID | NA | NA | NA | NA | Robert Forster |
| IL | 11.5 | 139177 | 298180 | 277 | Walker Kirby |
| IN | 2 | 12493 | 25769 | 39 | Don Scott |
| IA | 10 | 138484 | 261096 | 417 | Laura Sweets |
| KS | 10 | 15475 | 30195 | 150 | Douglas Jardine |
| KY | NA | NA | NA | NA | Donald Hershman |
| LA | NA | NA | NA | NA | Clayton Hollier |
| ME | | | | | |
| MD | 5 | 2199 | 5295 | 58 | Arvydas Grybauskas |
| MA | 7.5 | 0 | 0 | 50 | Dan Cooley |
| MI | NA | NA | NA | NA | Pat Hart |
| MN | 5 | 30186 | 58376 | 332 | Ward Stienstra |
| MS | 1.5 | 169 | 404 | 5 | William Moore |
| MO | 12.5 | 29687 | 57988 | 148 | Einar Palm |
| MT | 5 | 79 | 159 | 62 | Jack Riesselman |
| NE | 5 | 43503 | 80994 | 191 | David Wysong |
| NV | 10 | 0 | 0 | 0 | John Maxfield |
| NH | | | | | |
| NJ | 1.5 | 150 | 343 | 5 | Jack Springer |
| NM | 2.5 | 215 | 472 | 10 | Michael English |
| NY | 7.5 | 4249 | 9461 | 575 | Gary Bergstrom |
| NC | 10 | 9233 | 20566 | 134 | Harry Duncan |
| ND | 2 | 791 | 1561 | 34 | Marcia McMullen |
| OH | 7.5 | 30101 | 61988 | 212 | Patrick Lipps |
| OK | 8 | 484 | 1028 | 23 | Ervin Williams |
| OR | 5 | 230 | 574 | 34 | Paul Koepsell |
| PA | 5 | 5426 | 13588 | 316 | John Ayers |
| RI | | | | | |
| SC | 4.5 | 1301 | 2815 | 16 | Bruce Martin |
| SD | 5 | 10574 | 19927 | 134 | Dale Gallenberg |
| TN | 15 | 8544 | 18448 | 249 | Melvin Newman |
| TX | 1.5 | 2133 | 4712 | 13 | Wendell Horne |
| UT | 5 | 143 | 270 | 52 | Sherman Thomson |
| VT | 10 | 0 | 0 | 135 | Al Gotlieb |
| VA | 4 | 1183 | 2711 | 106 | Erik Stromberg |
| WA | 0 | 0 | 0 | 0 | Otis Maloy |
| WV | 4 | 199 | 436 | 15 | John Baniecki |
| WI | 12.5 | 37041 | 78365 | 1316 | Craig Grau |
| WY | 10 | 567 | 1067 | 75 | Paul Vincelli |

Table 5. Field corn diseases without adequate controls.

| STATE | Diseases currently causing economic losses* | Information source |
|---|---|---|
| AL | | |
| AZ | none | Richard Hine |
| AR | | |
| CA | FER | Mike Davis |
| CO | SR,FSR,GSR,HS | Bob Croissant |
| CT | | |
| DE | FSR, ASR | Bob Mulrooney |
| FL | none | Tom Kucharek |
| GA | CR | James Hadden |
| ID | FSR,CS | Robert Forster |
| IL | none | Walker Kirby |
| IN | SR | Don Scott |
| IA | SR,GLS,ES,ER | Laura Sweets |
| KS | SR | Douglas Jardine |
| KY | SR,ER | Donald Hershman |
| LA | none | Clayton Hollier |
| ME | | |
| MD | GLS | Arvydas Grybauskas |
| MA | ER | Dan Cooley |
| MI | CS | Pat Hart |
| MN | none | Ward Stienstra |
| MS | CS,CR | William Moore |
| MO | none | Einar Palm |
| MT | none | Jack Riesselman |
| NE | none | David Wysong |
| NV | none | John Maxfield |
| NH | | |
| NJ | NCLB,BS,GSR,ER,FSR | Jack Springer |
| NM | SR,MDMV,LB | Michael English |
| NY | GSR,ASR,NCLB,ES | Gary Bergstrom |
| NC | ALB,ASR,GLS,NCLB, MDMV,MCDV,NEMA | Harry Duncan |
| ND | ER,CS | Marcia McMullen |
| OH | NCLS | Patrick Lipps |
| OK | none | Ervin Williams |
| OR | none | Paul Koepsell |
| PA | none | John Ayers |
| RI | | |
| SC | SR,ER,AER,NEMA(5% loss) | Bruce Martin |
| SD | none | Dale Gallenberg |
| TN | R,GLS | Melvin Newman |
| TX | SoR | Wendell Horne |
| UT | none | Sherman Thomson |
| VT | none | Al Gotlieb |
| VA | GLS | Erik Stromberg |
| WA | GSR | Otis Maloy |
| WV | none | John Baniecki |
| WI | SR,ER | Craig Grau |
| WY | FSR | Paul Vincelli |

*Disease Abbreviations:
FSR=Fusarium stalk rot (*Fusarium moniliforme*)
GLS=Gray leaf spot (*Cercospora zeae-maydis*)
GSR=Gibberella stalk rot (*Gibberella zeae*)
NCLS=Northern corn leaf spot (*Cochliobolus carbonum*)
SR=Stalk rot (general)
CR=Common rust (*Puccinia sorghi*)
LB=Leaf blights (general)
MDMV=Maize dwarf mosaic virus
MCDV=Maize chlorotic dwarf virus
SoR=Southern rust (*Puccinia polysora*)
NEMA=nematodes (general)
FER=Fusarium ear rot
ES=Eyespot (*Kabatiella zeae*)
CS=Common smut (*Ustilago maydis*)
ER=Ear rot (general)
AER=Aspergillus ear rot (*Aspergillus flavus*)
HS=Head smut (*Sphacelotheca reiliana*)
ASR=Anthracnose stalk rot (*Colletotrichum graminicola*)
BS=Brown spot (*Physoderma maydis*)
ALB=Anthracnose leaf blight (*Colletotrichum graminicola*)
NCLB=Northern corn leaf blight (*Setosphaeria turcica*)
SCLB=Southern corn leaf blight (*Cochliobolus heterostrophus*)

Table 6. Seed treatment usage on corn inbred seed for hybrid seed production, 1985-1988.

| State | Area Planted* | % seed treated with fungicide: Total | captan | other | % loss without seed treatment | Information Source |
|---|---|---|---|---|---|---|
| HA | 1000 | 100 | 100 | metalaxyl | NA | Jeri Ooka |
| IA | 100000 | 100 | 95 | NA | 10 | Laura Sweets |
| IL | 65000 | 100 | 90 | 6(TCMTB),4(thiram+carboxin) | 8-1 | Walker Kirby |
| IN | NA | 100 | 80 | 10(carboxin),10(thiram) | 2 | Don Scott |
| KY | NA | 100 | most | thiram,mancozeb | NA | Bill Nesmith |
| MI | NA | 100 | 100 | 0 | NA | Pat Hart |
| MN | NA | 100 | 95 | NA | 5 | Ward Stienstra |
| NE | NA | 95 | 85 | NA | 5 | David Wysong |
| NC | NA | 100 | 100 | 0 | 10 | Harry Duncan |
| ND | NA | 100 | 100 | 0 | 2 | Marcia McMullen |
| OH | 25000 | 100 | 100 | 0 | 5-10 | Patrick Lipps |
| PA | 1500 | 100 | most | carboxin + thiram | 5 | John Ayers |
| SD | NA | 90 | 75 | 15 (thiram), trace(carboxin, metalaxyl) | <5 | Dale Gallenberg |
| TX | <5000 | 0 | 0 | 0 | 1-2 | Wendell Horne |
| WI | 50000 | 100 | 100 | 0 | 10-15 | Craig Grau |

*Not official statistics; estimates should not be considered reliable.

Table 7. Foliar fungicide usage on corn for hybrid seed production.

| State | Area Planted (Acres)* | % Acres treated w/ foliar fungicides: | Applications: | Targeted diseases | % Losses w/o foliar fungicides | Information Source |
|---|---|---|---|---|---|---|
| HA | 1000 | 90 mancozeb or chlorothalonil**** | 1-3 appl. | NCLB,SCLB,R | NA | Jeri Ooka |
| IA | 10000 | 35 mancozeb | 1 | ES,GLS,SCLB,NCLS,NCLB,R | 25 | Laura Sweets |
| IL | 65000 | 50 mancozeb | 1 appl. 2 wks after tassel | NCLB,SCLB,NCLS,R | 30 | Walker Kirby |
| IN | NA | 50 mancozeb | 2-4 appl. | SCLB,NCLB,NCLS,R | NA | Don Scott |
| KY | NA | <10 mancozeb | 1 | R,GLS,NCLB,SCLB | NA | Bill Nesmith |
| MI | NA | <20 mancozeb** | 1 | NCLS,ALB,SCLB | NA | Pat Hart |
| MN | NA | 20 mancozeb | 1 | ES,NCLB | NA | Ward Stienstra |
| NE | NA | 10-15 mancozeb | 1 | NCLB,SCLB,ES,YLB | 10 | David Wysong |
| NC | NA | 0 | | NA | | Harry Duncan |
| ND | NA | 0 | | NA | | Marcia McMullen |
| OH | 25000 | 100 mancozeb*** | 3-4 appl.start 1 wk before tassel | NCLB,SCLB,NCLS | 25 | Patrick Lipps |
| PA | 1500 | 30-50 mancozeb | 3-4 appl. | NCLB,NCLS | 35 | John Ayers |
| SD | NA | <5 mancozeb | | NCLB,SCLB,R | NA | Dale Gallenberg |
| TX | <5000 | 0 | | SoR (not controlled) | NA | Wendell Horne |
| WI | 100000 | 10-20 mancozeb, chlorothalonil | 1-3 appl. | NCLB,NCLS,R,ES | 15 | Craig Grau |

*Not official statistics:
estimates should not be considered reliable.

**Section 18 permit 1989 for propiconazole for control of ALB. 75% of acreage treated

***Section 18 for propiconazole

****Late plantings receive propiconazole for NCLB control

Disease Abbreviations:
SR=Stalk rot (general)
GLS=Gray leaf spot (Cercospora zeae-maydis)
GSR=Gibberella stalk rot (Gibberella zeae)
FSR=Fusarium stalk rot (Fusarium moniliforme)
NCLS=Northern corn leaf spot (Cochliobolus carbonum)
CS=common smut (Ustilago maydis)
ES=Eyespot (Kabatiella zeae)
ER=Ear rot (general)
YLB=Yellow leaf blight (Phyllosticta maydis)
SCLB=Southern corn leaf blight (Cochliobolus heterostrophus)
R=Rusts (general)
ALB=Anthracnose leaf blight (Colletotrichum graminicola)
SoR=Southern rust (Puccinia polysora)
NCLB=Northern corn leaf blight (Setosphaeria turcica)

Table 8. Typical fungicide formulations labeled (1985-1988) for use on corn for hybrid seed production.

| Fungicide | Formulated products | %A.I. | Application rate (Amount/A) product | A.I. |
|---|---|---|---|---|
| chlorothalonil | Bravo 500 | 40 | 1.1-2.8 pt | 0.44-1.1 pt |
| | Bravo 720 | 54 | 0.75-2.0 pt | 0.41-1.1 pt |
| | Bravo 90 DG | 90 | 0.63-1.5 pt | 0.56-1.4 pt |
| mancozeb | Manzate 200 DF | 75 | 1.5 lb | 1.1 lb |

Labeled uses: Helminthosporium leaf blights
(i.e., southern leaf blight, northern leaf blight, northern leaf spot)

Timing: Apply every 4 to 7 days when symptoms begin, up to 40 (Manzate) or 14 (Bravo) days to harvest.

Table 9. Popcorn seed treatment usage, 1985-1988.

| State | 1985-1988 Area Planted (Acres) | % seed treated with fungicide: Total | captan | other | Estimated % loss w/o seed fungicides | Information source: |
|---|---|---|---|---|---|---|
| CA | 1000 | 100 | 100 | 0 | <1 | Mike Davis |
| CO | <5000 | 100 | NA | NA | 0 | Bob Croissant |
| IA | 35000 | 100 | 100 | 0 | NA | Laura Sweets |
| IL | 25000 | 100 | 90 | 6(TCMTB),4(thiram + carboxin) | 8-15 | Walker Kirby |
| IN | 60000 | 100 | 80 | 15(thiram),5(carboxin) | 2 | Don Scott |
| KS | 3000 | 100 | 100 | 0 | 10 | Douglas Jardine |
| KY | 20000 | 95 | 90 | thiram, some maneb, mancozeb, zineb | NA | Donald Hershman |
| MO | 14200 | 100 | 90 | 10(thiram, metalaxyl combinations) | 10-15 | Einar Palm |
| NE | 34200 | 95 | 85 | 15 (carboxin)* | 5 | David Wysong |
| OH | 18000 | 100 | 100 | 0 | 5-10 | Patrick Lipps |
| OR | <1000 | 100 | 70 | 30(thiram) | 5 | Paul Koepsell |
| SD | NA | 90 | 75 | 15(thiram), trace(carboxin, metalaxyl) | <5 | Dale Gallenberg |
| TN | <1000 | 85 | 80 | 5(thiram) | 15 | Melvin Newman |

*carboxin for control of head smut

Table 10. Foliar fungicide usage on popcorn, 1985-1988

| State | 1985-1988 Area Planted (Acres) | % Acres treated w/ foliar fungicides | Targeted diseases: | Estimated % loss w/o foliar treatment | Diseases currently causing economic losses: | Information Source: |
|---|---|---|---|---|---|---|
| CA | 1000 | | | NA | FER | Mike Davis |
| CO | <5000 | 0 | | 0 | SR | Bob Croissant |
| IA | 35000 | 0 | | 0 | DER,AER | Laura Sweets |
| IL | 25000 | 30% (mancozeb) | NCLB,SCLB, NCLS,R | 30 | NCLB,SCLB,NCLS,R | Walker Kirby |
| IN | 60000 | 0 | | NA | SR | Don Scott |
| KS | 3000 | 4% (mancozeb) | R, NCLB | NA | none | Douglas Jardine |
| KY | 20000 | 0 | | NA | none | Donald Hershman |
| MO | 14200 | 0 | | NA | none | Einar Palm |
| NE | 34200 | 0 | | NA | none | David Wysong |
| OH | 18000 | 0 | | NA | none | Patrick Lipps |
| OR | <1000 | 0 | | NA | none | Paul Koepsell |
| SD | NA | <5% (mancozeb) | NCLB,SCLB,R | NA | none | Dale Gallenberg |
| TN | <1000 | 0 | | NA | R,GLS | Melvin Newman |

Disease Abbreviations:
SR=Stalk rot (general)
DER=Diplodia ear rot (Stenocarpella maydis)
AER=Aspergillus ear rot (Aspergillus flavus)
FER=Fusarium ear rot
NCLB=Northern corn leaf blight (Setosphaeria turcica)
SCLB=Southern corn leaf blight (Cochliobolus heterostrophus)
NCLS=Northern corn leaf spot (Cochliobolus carbonum)
R=rusts (general)
GLS=Grey leaf spot (Cercospora zeae-maydis)

Table 11. Typical foliar fungicide formulations labeled (1985-1988) for use on popcorn.

| Fungicide | Formulated products | % A.I. | Application rate (Amount/A) product | A.I. |
|---|---|---|---|---|
| mancozeb | Dithane M-45 | 80 | 1.5 lb | 1.2 lb |
| | Dithane F-45 | 37 | 1.2 qt | 0.44 qt |
| | Dithane-DF | 75 | 1.5 lb | 1.1 lb |
| | Manzate 200DF | 75 | 1.5 lb | 1.1 lb |
| | Penncozeb | 80 | 1.5 lb | 1.2 lb |
| | Penncozeb DF | 75 | 1.5 lb | 1.1 lb |

Labeled uses: Helminthosporium leaf blights
(i.e. southern leaf blight, northern leaf blight, northern leaf spot)
rust (not on Penncozeb label)

Timing: Apply every 4 to 7 days when symptoms begin, up to 40 (Manzate) or 7 (Dithane, Penncozeb) days to harvest

Table 12. Seed treatment fungicide usage on rapeseed, 1985-1988.

| State | 1985-1988 Acreage (Acres) | % Seed treated with fungicide: treatment (%) | Estimated loss without seed | Target diseases | Diseases currently causing economic loss | Information source |
|---|---|---|---|---|---|---|
| DE | NA | 0 | NA | | none | Bob Mulrooney |
| GA | 3500 | 100 (benomyl) | NA | BL | CLS, ALS | James Hadden |
| ID | NA | NA | NA | | NA | Robert Forster |
| IL | 20000 | <5 (benomyl) | NA | BL | S,BL,ALS | Walker Kirby |
| IN | <10000 | 0 | NA | | S,RRR | Don Scott |
| KY | 4500 | 75 (benomyl) | NA | BL | S,BL,RRR,ALS,SD | Don Hershman |
| MI | NA | 0 | NA | | none | Pat Hart |
| MT | 0* | | | | none | Jack Riesselman |
| ND | 50000 | 100 (benomyl) | 10 | BL | S | Marcia McMullen |
| OR | 2000 | 0 | | | none | Paul Koepsell |
| SC | <2000 | 0 | | | S | Bruce Martin |
| TN | 9000** | 100 (benomyl) | NA | BL | ALS | Melvin Newman |
| WA | NA | 0 | NA | BL*** | none | Otis Maloy |
| WY | <500 | 0 | NA | | PRR | Paul Vincelli |

*500,000 acres expected in 1990
**14,000 acres industrial rapeseed in western TN
<5,000 acres canola in middle & east TN
***Concerned about ascospore inoculum for cabbage seed production

Disease Abbreviations:
PRR=Phytophthora root rot
RRR=Rhizoctonia root rot
S=Sclerotinia stem rot
CLS=Cercospora leaf spot
BL=Phoma blackleg
ALS=Alternaria leaf spot
SD=Seed decay

Table 13. Typical fungicide formulations labeled (1985-1988) for seed treatment of rapeseed (canola).

| Fungicide | Formulated products | Method* | %A.I. | Application rate (oz/cwt.) product | A.I. |
|---|---|---|---|---|---|
| benomyl | Benlate 50 WP | C | 50 | 8.0 | 4.0 |
| | Benlate 50 DF | C | 50 | 8.0 | 4.0 |
| captan | Captan 30 DD | C | 30 | 1.5 | 0.45 |
| | Captan 300 | C | 30 | 1.5 | 0.45 |
| | Captan 400 | C | 38 | 1.0-2.0 | 0.4-0.76 |
| | Captan 400 D | C | 38 | 1.0-2.0 | 0.4-0.76 |

Labeled uses: seedborne black leg (benomyl)
seed decay and seedling blights (captan)

*Registered for application by commercially certified seed treaters (C).

Table 14. Sunflower production statistics by state.

| State | 1985-1988 Area planted (1000 Acres) | % US Acreage (1000 Acres) | 1985-1988 Area harvested Acre (Pounds) | 1985-1988 Yield/Harvested (1000 Pounds) | 1985-1988 Production (1000 Dollars) | 1985-1988 %US Production | 1985-1987 Value of Prod. |
|---|---|---|---|---|---|---|---|
| CA | 1 | 0.06 | NA | NA | NA | NA | NA |
| KS | 200 | 9.07 | NA | 1200 | NA | NA | NA |
| MI | 23 | 1.04 | NA | NA | NA | NA | NA |
| MN | 137 | 6.20 | 126 | 1308 | 154020 | 6.12 | 13887 |
| ND | 1662 | 75.35 | 1576 | 1212 | 1882460 | 74.85 | 154618 |
| OH | NA | NA | NA | NA | NA | NA | NA |
| OK | <3 | NA | NA | NA | NA | NA | NA |
| SD | 365 | 16.55 | 361 | 1179 | 427818 | 17.01 | 34233 |
| TX | 41 | 1.86 | 39 | 1285 | 50525 | 2.01 | 5288 |
| WA | NA | NA | NA | NA | NA | NA | NA |
| US | 2206 | 100.00 | 2095 | 1212 | 2514823 | 100.00 | 207908 |

Table 15. Seed treatment fungicide usage on sunflower, 1985-1988.

| State | 1985-1988 Area planted (1000 Acres) | % US Acreage | 1985-1988 Production (1000 Pounds) | 1985-1987 Value of Prod. (1000 Dollars) | % Seed treated w/fungicides | % Loss in absence of seed treatment | Estimated Loss (1000 Pounds) | Estimated$ Loss (1000 Dollars) | Information Source |
|---|---|---|---|---|---|---|---|---|---|
| CA | 1 | 0.05 | NA | NA | 100 metalaxyl* | NA | NA | NA | Mike Davis |
| CO | NA | NA | NA | NA | 90(chemical (unknown) | NA | NA | NA | Bob Croissant |
| KS | 200 | 9.07 | NA | NA | 0 | NA | NA | NA | Douglas Jardine |
| MI | 23 | 1.04 | NA | NA | NA | NA | NA | NA | Pat Hart |
| MN | 137 | 6.20 | 154020 | 13887 | NA | NA | NA | NA | Ward Stienstra |
| ND | 1662 | 75.35 | 1882460 | 154618 | 80-90 (metalaxyl) | 5** | 80005 | 6571 | Marcia McMullen |
| OH | NA | NA | NA | NA | 100 captan | NA | NA | NA | Patrick Lipps |
| OK | <3 | NA | NA | NA | NA | NA | NA | NA | Ervin Williams |
| SD | 365 | 16.55 | 427818 | 34233 | 10 metalaxyl | NA | NA | NA | Dale Gallenberg |
| TX | 41 | 1.86 | 50525 | 5288 | 60 captan, 40 thiram | 4.5*** | 2275 | 238 | Wendell Horne |
| WA | NA | NA | NA | NA | 0 | NA | NA | NA | Otis Maloy |
| US | 2206 | 100.00 | 2514823 | 207908 | | | | | |

*metalaxyl 1990 only, for seed contaminated with downy mildew
**losses to downy mildew
***losses to seed decay/seedling blight

Table 16. Typical fungicide formulations labeled (1985-1988) for seed treatment of sunflower.

| Fungicide | Formulated products | Method* | % A.I. | Application rate (oz/cwt) product | A.I. |
|---|---|---|---|---|---|
| captan | Captan 30 DD | C | 30 | 4.0 | 1.2 |
| | Captan 300 | C | 30 | 4.0 | 1.2 |
| | Captan 400 | C | 38 | 2.0-4.0 | 0.7-1.5 |
| | Captan 400 D | C | 38 | 2.0-4.0 | 0.7-1.5 |
| metalaxyl | Apron Dry | PB | 13 | 8.0 | 1.0 |
| | Apron 25W | C | 25 | 8.0-14.0 | 2.0-3.5 |
| | Apron FL | C | 28.4 | 3.0 | 0.85 |
| | Apron Flowable | C | 28.4 | 3.0 | 0.85 |
| thiram | Thiram 30 | C | 30 | 2.75 | 0.83 |

Labeled uses: systemic downy mildew (metalaxyl)
seed decay and seedling blights (captan and thiram)

*Registered for application by commercially certified seed treaters (C) or for on-farm application in the planter box (PB)

Table 17. Hay production statistics by state

| STATE | 1985-1988 Alfalfa hay Area harvested (1000 Acres) | 1985-1988 % US Acreage | 1985-1988 Alfalfa hay Yield/Harvested Acre (tons) | 1985-1988 Alfalfa hay Production (1000 tons) | 1985-1988 %US prod. Alfalfa hay | 1985-1988 All other hay Area harvested (1000 acres) | 1985-1988 All other hay Yield/Harvested Acre (tons) | 1985-1988 All other Hay Production (1000 tons) | 1985-1988 %US prod Other hay | 1985-1988 All Hay Value of prod. (1000 dollars) | 1985-1988 %US Hay Prod. $ Value |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AL | | | | | | 713 | 1.98 | 1408 | 2.26 | 87663 | 0.97 |
| AZ | 154 | 0.59 | 7.60 | 1170 | 1.42 | 25 | 3.98 | 99 | 0.16 | 97309 | 1.08 |
| AR | 37 | 0.14 | 2.73 | 100 | 0.12 | 939 | 1.80 | 1689 | 2.71 | 93525 | 1.03 |
| CA | 1090 | 4.17 | 6.60 | 7197 | 8.71 | 560 | 2.45 | 1372 | 2.20 | 669694 | 7.40 |
| CO | 800 | 3.06 | 3.40 | 2720 | 3.29 | 701 | 1.58 | 1102 | 1.77 | 223831 | 2.47 |
| CT | 21 | 0.08 | 2.67 | 56 | 0.07 | 65 | 2.60 | 138 | 0.22 | 19058 | 0.21 |
| DE | 8 | 0.03 | 3.35 | 27 | 0.03 | 16 | 1.96 | 30 | 0.05 | 5335 | 0.06 |
| FL | | | | | | 261 | 2.70 | 707 | 1.13 | 52422 | 0.58 |
| GA | | | | | | 549 | 2.15 | 1178 | 1.89 | 73964 | 0.82 |
| ID | 1015 | 3.88 | 3.75 | 3806 | 4.61 | 267 | 1.84 | 490 | 0.79 | 249195 | 2.75 |
| IL | 738 | 2.82 | 3.65 | 2615 | 3.17 | 453 | 2.10 | 939 | 1.50 | 211020 | 2.33 |
| IN | 413 | 1.58 | 3.45 | 1410 | 1.71 | 399 | 2.05 | 800 | 1.28 | 125524 | 1.39 |
| IA | 1750 | 6.69 | 3.42 | 5743 | 6.95 | 637 | 2.08 | 1464 | 2.34 | 316779 | 3.50 |
| KS | 863 | 3.30 | 3.73 | 3230 | 3.91 | 1650 | 1.73 | 2835 | 4.54 | 313110 | 3.46 |
| KY | 271 | 1.04 | 3.23 | 868 | 1.05 | 1748 | 1.78 | 3080 | 4.93 | 266300 | 2.94 |
| LA | 12 | 0.05 | 2.72 | 33 | 0.04 | 322 | 2.52 | 814 | 1.30 | 40133 | 0.44 |
| ME | 23 | 0.09 | 2.42 | 58 | 0.07 | 197 | 1.89 | 371 | 0.59 | 29955 | 0.33 |
| MD | 80 | 0.31 | 3.65 | 292 | 0.35 | 149 | 2.13 | 317 | 0.51 | 58928 | 0.65 |
| MA | 30 | 0.12 | 2.78 | 83 | 0.10 | 95 | 2.23 | 213 | 0.34 | 27288 | 0.30 |
| MI | 1320 | 5.05 | 3.25 | 4309 | 5.22 | 410 | 1.78 | 704 | 1.13 | 283620 | 3.13 |
| MN | 1969 | 7.53 | 3.15 | 6035 | 7.30 | 1081 | 2.00 | 2064 | 3.31 | 511846 | 5.66 |
| MS | | | | | | 631 | 2.13 | 1296 | 2.08 | 64037 | 0.71 |
| MO | 423 | 1.62 | 2.75 | 1167 | 1.41 | 3158 | 1.54 | 4803 | 7.70 | 364389 | 4.03 |
| MT | 1162 | 4.45 | 2.05 | 2413 | 2.92 | 888 | 1.24 | 1107 | 1.77 | 220645 | 2.44 |
| NE | 1337 | 5.11 | 3.34 | 4461 | 5.40 | 1950 | 1.19 | 2321 | 3.72 | 265713 | 2.94 |
| NV | 243 | 0.93 | 4.15 | 1007 | 1.22 | 268 | 1.27 | 342 | 0.55 | 105448 | 1.17 |
| NH | 21 | 0.08 | 2.67 | 55 | 0.07 | 66 | 2.09 | 137 | 0.22 | 18154 | 0.20 |
| NJ | 41 | 0.16 | 3.45 | 143 | 0.17 | 73 | 2.10 | 151 | 0.24 | 29997 | 0.33 |
| NM | 237 | 0.91 | 5.05 | 1200 | 1.45 | 68 | 1.75 | 118 | 0.19 | 110832 | 1.22 |
| NY | 939 | 3.59 | 2.79 | 2616 | 3.17 | 1278 | 2.04 | 2606 | 4.18 | 387904 | 4.29 |
| NC | 32 | 0.12 | 2.56 | 80 | 0.10 | 392 | 1.59 | 622 | 1.00 | 58121 | 0.64 |
| ND | 1413 | 5.40 | 1.54 | 2286 | 2.77 | 1538 | 1.14 | 1713 | 2.74 | 192329 | 2.13 |
| OH | 720 | 2.75 | 3.58 | 2572 | 3.11 | 776 | 2.15 | 1646 | 2.64 | 294144 | 3.25 |
| OK | 412 | 1.58 | 3.45 | 1423 | 1.72 | 1737 | 1.70 | 2935 | 4.70 | 260112 | 2.87 |
| OR | 439 | 1.68 | 4.14 | 1816 | 2.20 | 655 | 1.78 | 1162 | 1.86 | 217464 | 2.40 |
| PA | 842 | 3.22 | 3.15 | 2654 | 3.21 | 1172 | 2.07 | 2431 | 3.89 | 406677 | 4.49 |
| RI | 3 | 0.01 | 2.79 | 8 | 0.01 | 6 | 2.17 | 13 | 0.02 | 2220 | 0.02 |
| SC | | | | | | 219 | 2.03 | 443 | 0.71 | 29750 | 0.33 |
| SD | 2213 | 8.46 | 1.87 | 4240 | 5.13 | 1850 | 1.10 | 2050 | 3.28 | 266178 | 2.94 |
| TN | 110 | 0.42 | 2.90 | 323 | 0.39 | 1808 | 1.55 | 2228 | 3.57 | 146596 | 1.62 |
| TX | 147 | 0.56 | 4.03 | 603 | 0.73 | 3153 | 2.10 | 6626 | 10.62 | 507638 | 5.61 |
| UT | 469 | 1.79 | 3.95 | 1852 | 2.24 | 150 | 1.99 | 298 | 0.48 | 141116 | 1.56 |
| VT | 115 | 0.44 | 2.43 | 280 | 0.34 | 310 | 1.93 | 598 | 0.96 | 71855 | 0.79 |
| VA | 110 | 0.42 | 2.85 | 315 | 0.38 | 1050 | 1.48 | 1554 | 2.49 | 155492 | 1.72 |
| WA | 468 | 1.79 | 4.15 | 1941 | 2.35 | 330 | 2.45 | 809 | 1.30 | 181385 | 2.00 |
| WV | 87 | 0.33 | 2.65 | 235 | 0.28 | 520 | 1.43 | 741 | 1.19 | 58502 | 0.65 |
| WI | 3038 | 11.62 | 2.60 | 7888 | 9.55 | 550 | 1.95 | 1037 | 1.66 | 613758 | 6.78 |
| WY | 533 | 2.04 | 2.40 | 1283 | 1.55 | 635 | 1.27 | 804 | 1.29 | 122061 | 1.35 |
| US | 26145 | 100.00 | 3.16 | 82609 | 100.00 | 36142 | 1.74 | 62413 | 100.00 | 9050541 | 100.00 |

Source: USDA Economic Research Service

Table 18. Seed treatment fungicide usage on alfalfa, 1985-1988.

| State | 1985-1988 Alfalfa hay Area harvested (1000 acres) | 1985-1988 % US Acreage | 1985-1988 Alfalfa Hay Production (1000 tons) | 1985-1988 % US Production Alfalfa hay | % seed treated with fungicide: Total | metalaxyl | other | Diseases targeted: | % losses in absence of seed treatment fungicides | Information Source |
|---|---|---|---|---|---|---|---|---|---|---|
| AL | | | | | | | | | | |
| AZ | 154 | 0.59 | 1170 | 1.42 | 0 | 0 | 0 | | 0 | Robert Hine |
| AR | 37 | 0.14 | 100 | 0.12 | | | | | | |
| CA | 1090 | 4.17 | 7197 | 8.71 | <5 | 0 | 0 | PyRR,PRR | NA | Mike Davis |
| CO | 800 | 3.06 | 2720 | 3.29 | <50 | NA | NA | PyRR,PRR | <1 | Bob Croissant |
| CT | 21 | 0.08 | 56 | 0.07 | | | | | | |
| DE | 8 | 0.03 | 27 | 0.03 | | | | | | |
| FL | | | | | | | | | | |
| GA | | | | | | | | | | |
| ID | 1015 | 3.88 | 3806 | 4.61 | 100 | 100 | 0 | PyRR,PRR | NA | Robert Forster |
| IL | 738 | 2.82 | 2615 | 3.17 | 55 | 50 | 1-2 (carboxin + thiram)<br><1 thiram | PyRR, PRR | 20-25 | Walker Kirby |
| IN | 413 | 1.58 | 1410 | 1.71 | 25 | 25 | 0 | PRR | 5 | Don Scott |
| IA | 1750 | 6.69 | 5743 | 6.95 | 50 | 50 | 0 | PRR, PyRR | NA | Laura Sweets |
| KS | 863 | 3.30 | 3230 | 3.91 | 10 | 10 | 0 | PRR, PyRR | NA | Douglas Jardine |
| KY | 271 | 1.04 | 868 | 1.05 | 15 | 15 | 0 | PyRR | 0 | Bill Nesmith |
| LA | 12 | 0.05 | 33 | 0.04 | | | | | | |
| ME | 23 | 0.09 | 58 | 0.07 | | | | | | |
| MD | 80 | 0.31 | 292 | 0.35 | 60 | 60 | 0 | PyRR,PRR | NA | Arvydas Grybauskas |
| MA | 30 | 0.12 | 83 | 0.10 | 30 | 30 | 0 | PyRR,PRR | 10 | Dan Cooley |
| MI | 1320 | 5.05 | 4309 | 5.22 | <10 | <10 | 0 | PRR, PyRR | NA | Pat Hart |
| MN | 1969 | 7.53 | 6035 | 7.30 | 5 | 5 | 0 | PyRR,PRR | NA | Ward Stienstra |
| MS | | | | | | | | | | |
| MO | 423 | 1.62 | 1167 | 1.41 | <5 | <5 | 0 | PyRR,PRR | NA | Einar Palm |
| MT | 1162 | 4.45 | 2413 | 2.92 | | <10 | 3(thiram) | PyRR,PRR | 2 | Jack Riesselman |
| NE | 1337 | 5.11 | 4461 | 5.40 | <5 | <5 | 0 | PyRR,PRR | 5 | John Watkins |
| NV | 243 | 0.93 | 1007 | 1.22 | 80 | 80 | 0 | PyRR,PRR | 15 | John Maxfield |
| NH | 21 | 0.08 | 55 | 0.07 | | | | | | |
| NJ | 41 | 0.16 | 143 | 0.17 | 60 | 60 | 0 | PyRR,PRR | >10 | Jack Springer |
| NM | 237 | 0.91 | 1200 | 1.45 | | | | PyRR,PRR | NA | Michael English |
| NY | 939 | 3.59 | 2616 | 3.17 | 30 | 30 | 0 | PRR,PyRR | 7 | Gary Bergstrom |
| NC | 32 | 0.12 | 80 | 0.10 | 50 | 50 | 0 | PyRR,PRR | NA | Jack Bailey |
| ND | 1413 | 5.40 | 2286 | 2.77 | <5 | <5 | 0 | PyRR,PRR | NA | Marcia McMullen |
| OH | 720 | 2.75 | 2572 | 3.11 | 50* | 50 | 0 | PRR,PyRR | 10-20 | Lanny Rhodes |
| OK | 412 | 1.58 | 1423 | 1.72 | 0 | 0 | 0 | | NA | Ervin Williams |
| OR | 439 | 1.68 | 1816 | 2.20 | <5 | NA | NA | PyRR,PRR | NA | Paul Koepsell |
| PA | 842 | 3.22 | 2654 | 3.21 | 27 | 27 | 0 | PyRR,PRR | NA | Ken Leath |
| RI | 3 | 0.01 | 8 | 0.01 | | | | | | |
| SC | | | | | 0 | 0 | 0 | | NA | Bruce Martin |
| SD | 2213 | 8.46 | 4240 | 5.13 | 10 | 10 | 0 | PyRR,PRR | 5-10 | Dale Gallenberg |
| TN | 110 | 0.42 | 323 | 0.39 | 0 | 0 | 0 | | NA | Melvin Newman |
| TX | 147 | 0.56 | 603 | 0.73 | 0 | 0 | 0 | | NA | Wendell Horne |
| UT | 469 | 1.79 | 1852 | 2.24 | <10 | <10 | 0 | PyRR,PRR | NA | Sherman Thomson |
| VT | 115 | 0.44 | 280 | 0.34 | 50 | 20 | 50(thiram)** | PyRR,PRR,VW | 10 | Al Gotlieb |
| VA | 110 | 0.42 | 315 | 0.38 | 80 | 80 | 0 | PyRR,PRR | 25*** | Erik Stromberg |
| WA | 468 | 1.79 | 1941 | 2.35 | <5 | <5 | 0 | PyRR,PRR | NA | Otis Maloy |
| WV | 87 | 0.33 | 235 | 0.28 | <5 | <5 | 0 | PyRR,PRR | NA | John Baniecki |

Table 18 (continued)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| WI | 3038 | 11.62 | 7888 | 9.55 | 70 | 70 | 0 | PRR, PyRR | 10**** | Craig Grau |
| WY | 533 | 2.04 | 1283 | 1.55 | 5 | 5 | 0 | PyRR, PRR | 5 | Paul Vincelli |
| US | 26145 | 100.00 | 82609 | 100.00 | | | | | | |

*75% treated with metalaxyl in 1990; **Thiram applied by grower (to reduce introduction of Verticillium wilt); often in addition to metalaxyl applied by seed supplier; ***if metalaxyl unavailable, spring planting would be impossible; ****5-20% loss in seeding year. Disease Abbreviations: PRR = Phytophthora Root Rot (<u>Phytophthora megasperma</u>); PyRR = Pythium root rot/damping off; VW = Verticillium wilt (<u>Verticillium albo-atrum</u>).

Table 19. Typical fungicide formulations labeled (1985-1988) for seed treatment of alfalfa.

| Fungicide | Formulated products | Method* | %A.I. | Application rate (oz/cwt) product | A.I. |
|---|---|---|---|---|---|
| captan | Captan 30 DD | C | 30 | 6.5 | 2.0 |
| | Captan 300 | C | 30 | 6.5 | 2.0 |
| | Captan 400 | C | 38 | 5.0-8.0 | 2.0-3.0 |
| | Captan 400 D | C | 38 | 5.0-8.0 | 2.0-3.0 |
| | Captan 75% | C | 75 | 3.33 | 2.5 |
| | Captan 4000 | C | 38 | 3.25 | 1.2 |
| metalaxyl | Apron Dry | PB | 13 | 4.0 | 0.5 |
| | Apron 25W | C | 25 | 2.0 | 0.5 |
| | Apron FL | C | 28.4 | 0.75-1.5 | 0.21-0.43 |
| | Apron Flowable | C | 28.4 | 0.75-1.5 | 0.21-0.43 |
| thiram | Thiram 30 | C | 30 | 6.6-11.0 | 2.0-3.3 |
| | Gustafson 42-S | C | 42 | 8.0 | 3.4 |
| | Thiram 50 WP | C | 50 | 8.0 | 4.0 |
| | Yield Shield | PB | 13 | 12 | 1.6 |

Labeled uses: Pythium damping-off and early season Phytophthora root rot (metalaxyl)
seed decay and seedling blight (captan and thiram)

*Registered for application by commercially certified seed treaters (C) or for on-farm application in the planter box (PB)

Table 20. Typical fungicide formulations labeled (1985-1988) for control of fungal leaf spots on alfalfa

| Fungicide | Formulated products | %A.I. | Application rate (Amount/A) product | A.I. |
|---|---|---|---|---|
| copper | Kocide 101 | 77 | 2 lb | 1.5 lb |
| | Kocide 606 | 38 | 2.67 pt | 1 pt |
| | Top Cop Tri Basic | 29 | 1 qt | 0.3 qt |

Labeled uses: Cercospora leaf spot
Leptosphaerulina leaf spot

Other information: Use 10-14 days before harvest; ground or air

Table 21. Alfalfa diseases without adequate controls.

| STATE | Diseases currently causing economic losses: (% loss estimates) | Information Source |
|---|---|---|
| AL | | |
| AZ | none | Richard Hine |
| AR | | |
| CA | none | Mike Davis |
| CO | LS,SN | Bob Croissant |
| CT | | |
| DE | PRR,LS,CR | Bob Mulrooney |
| FL | | |
| GA | | |
| ID | none | Robert Forster |
| IL | LS* | Walker Kirby |
| IN | LS,A,CR** | Don Scott |
| IA | PRR,SB,LS,A,VW | Laura Sweets |
| KS | none | Douglas Jardine |
| KY | LS,S | Bill Nesmith |
| LA | | |
| ME | | |
| MD | S,LS,VW | Arvydas Grybauskas |
| MA | LS,S | Dan Cooley |
| MI | none | Pat Hart |
| MN | CLS, LLS | Ward Stienstra |
| MS | | |
| MO | LS,CR | Einar Palm |
| MT | | Jack Riesselman |
| NE | A,SBS,SuBS,R,DM | John Watkins |
| NV | none | John Maxfield |
| NH | | |
| NJ | CLS,LLS,CR,SBS | Jack Springer |
| NM | Phym | Michael English |
| NY | PRR,CR,SBS,LLS | Gary Bergstrom |
| NC | LLS, SuBS,A,CR,V | Jack Bailey |
| ND | NA | Marcia McMullen |
| OH | S(20),PRR(7.5),SBS(10) VW(trace) | Lanny Rhodes |
| OK | none | Ervin Williams |
| OR | none | Paul Koepsell |
| PA | minimal | Ken Leath |
| RI | | |
| SC | | Bruce Martin |
| SD | LS,SBS,SuBS | Dale Gallenberg |
| TN | CR,LLS | Melvin Newman |
| TX | Phym | Wendell Horne |
| UT | none | Sherman Thompson |
| VT | FW | Al Gotlieb |
| VA | S,LS | Erik Stromberg |
| WA | DM,VW,SN (in seed production) | Otis Maloy |
| WV | LS,CR | John Baniecki |
| WI | LS***,S,V,CR,SBS | Craig Grau |
| WY | none | Paul Vincelli |
| US | | |

Disease Abbreviations:
PRR=Phytophthora Root Rot (*Phytophthora megasperma*)
PyRR=Pythium root rot/damping off
LS=leaf spots (general)
A=Anthracnose (*Colletotrichum trifolii*)
S=Sclerotinia crown and stem rot (*Sclerotinium trifoliorum*)
VW=Verticillium wilt (*Verticillium albo-atrum*)
LLS=Lepto leaf spot (*Leptosphaerulina briosiana*)
CLS=Common leaf spot (*Pseudopeziza medicagninis*)
SB=Seedling blight (general)
CR=Crown and root rot (general)
SBS=Spring black stem (*Phoma medicaginis*)
SuBS=Summer black stem (*Cercospora medicaginis*)
R=Alfalfa rust (*Uromyces striatus*)
V=Viruses (general)
Phym=Phymatotrichum root rot
DM=Downy mildew (*Peronspora trifoliorum*)
FW=Fusarium wilt (*Fusarium oxysporum* f.sp.*medicaginis*)
SN=Stem nematode

*Research indicates a 200% return on investment using mancozeb (not labeled) for control of leaf spot complex
**Combined loss ranges 5-30%, average 10%
***Research indicates 20% yield increase with mancozeb or benomyl

Table 22. Typical fungicide formulations labeled (1985-1988) for seed treatment of forage grasses.

| Fungicide | Formulated products | Method* | % A.I. | Application rate (oz/cwt) product | A.I. |
|---|---|---|---|---|---|
| captan | Captan 30 DD | C | 30 | 6.5 | 2.0 |
| | Captan 300 | C | 30 | 6.5 | 2.0 |
| | Captan 400 | C | 38 | 5.0-8.25 | 2.0-3.0 |
| | Captan 400 D | C | 38 | 5.0-8.25 | 2.0-3.0 |
| | Captan 4000 | C | 38 | 8.25 | 3.1 |
| metalaxyl | Apron Dry | PB | 13 | 3.0-4.0 | 0.4-0.5 |
| | Apron 25W | C | 25 | 1.0-2.0 | 0.3-0.5 |
| | Apron FL | C | 28.4 | 0.75-1.5 | 2.1-4.3 |
| | Apron Flowable | C | 28.4 | 0.75-1.5 | 2.1-4.3 |
| thiram | Thiram 30 | C | 30 | 6.6-11.0 | 2.0 |
| | Gustafson 42-S | C | 42 | 8.0 | 3.4 |
| | Thiram 50 WP | C | 50 | 8.0 | 4.0 |

*Registered for application by commercially certified seed treaters (C) or for on-farm application in the planter box (PB)